It's Time for a Change!
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Agenda MSP430 Day 2004

- What is the MSP430?
- The Ultra-low Power Concept
- Device Derivatives
- Development Support
- Future Products

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What is The MSP430

Ultra-low Power

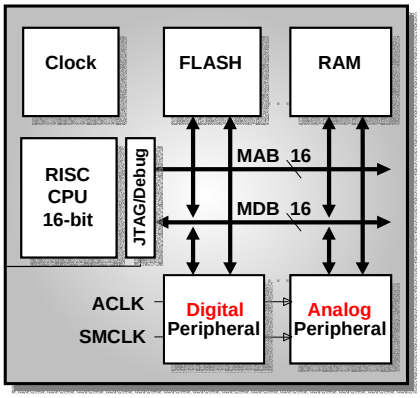
- 0.1uA power down
- 0.8uA standby mode
- 250uA / 1MIPS @ 3V
- <6us clock start-up
- <50nA port leakage
- Zero-power BOR

High-Performance

- Modern 16-bit RISC
- SCoC integration

Easy To Use IDE

- Get to market faster



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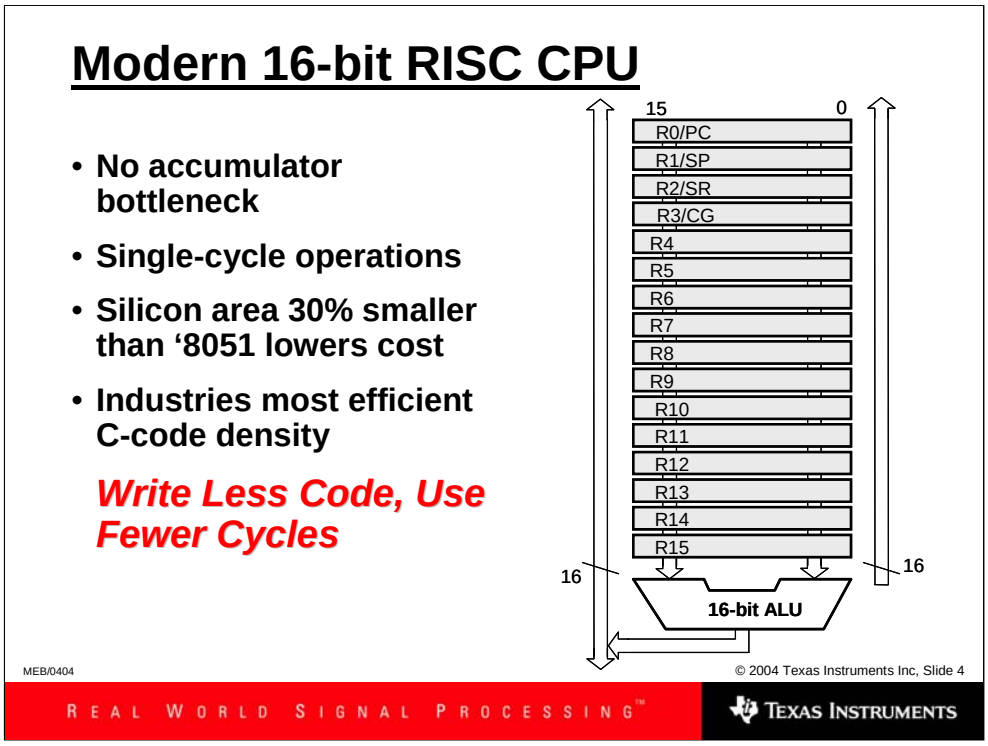
MSP430 stands for Mixed Signal Processor. The features of the MSP430 family make the product ideal for battery-powered measurement applications.

Ultra-low Power; The MSP430 architecture is designed specifically for ultra-low power applications – specific operating modes are implemented to reduced power consumption and dramatically extend battery life. The real-time clock mode uses as little as 0.8uA which is actually lower than the self leakage most batteries themselves. Many MSP430 customers have developed battery-based products that will last for over 10-years from the original battery!

Modern 16-bit RISC CPU; Because the MSP430 uses a modern 16-bit RISC CPU, engineers can embed advanced signal processing features into their products that was never practical with conventional 8-bit MCUs. And this is done using less power, less memory and at a lower cost.

Mixed Signal; Analog peripherals including ADC's, comparators, DAC's, LCD drivers and supply voltage supervisors are integrated to support precision measurement. These peripherals enable better products to be built using fewer chips.

Easy to use IDE; We'll see today how the MSP430's IDE is really easy to use. A Flash MSP430 is developed in the actual application with the actual application running. No monitor or background debugger is used. The debug logic is on-chip and dedicated for only debug. This is accessed with JTAG.



Modern 16-bit RISC CPU is optimized for modern programming techniques.

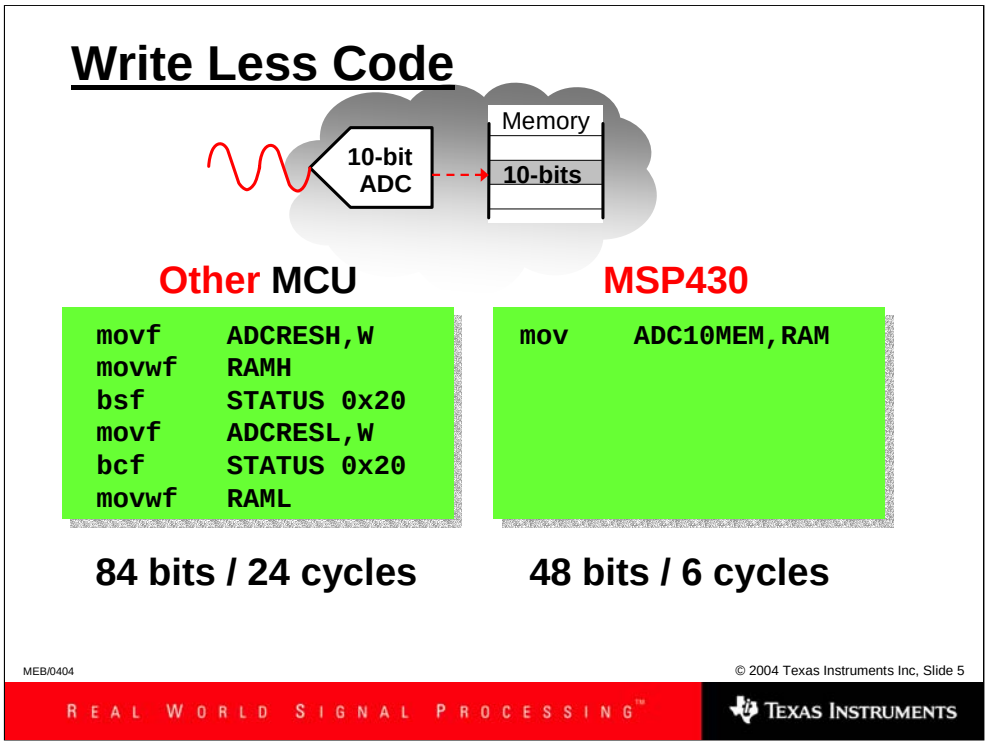
•The MSP430's architecture provides the flexibility of 16 fully addressable, single-cycle 16-bit CPU registers. The large CPU register file eliminates what is typically a single working file or accumulator bottleneck. The CPU registers are fully accessible including the program counter, stack pointer, status register and 12 working registers.

•The CPU also integrates a constant generator to automatically generate the six most used immediate values. The constant generator has the effect of reducing code size by generator this common constants (or literals) using hardware, eliminating what would be immediate values embedded in code.

•The modern Reduced Instruction Set (RISC) design of the CPU offers versatility through simplicity using only 27 easy-to-understand instructions and seven consistent addressing modes. All memory spaces – Flash, RAM, peripherals and CPU registers - use the exact same instructions and addressing modes. All instructions can also be used in a byte format as well. The MSP430 is an orthogonal design because all instructions are used consistently though all areas of the device.

•Up to 8 MIPS of performance is available today, with more planned.

•The result is a 16-bit, ultra-low power CPU that has more effective processing throughput, is smaller in size, and more code-efficient than other 8/16-bit microcontrollers. When using the MSP430, this results in programmers writing less lines of code. **Now it's possible to develop ultra-low power, high-performance applications at a fraction of the code size previously possible.**

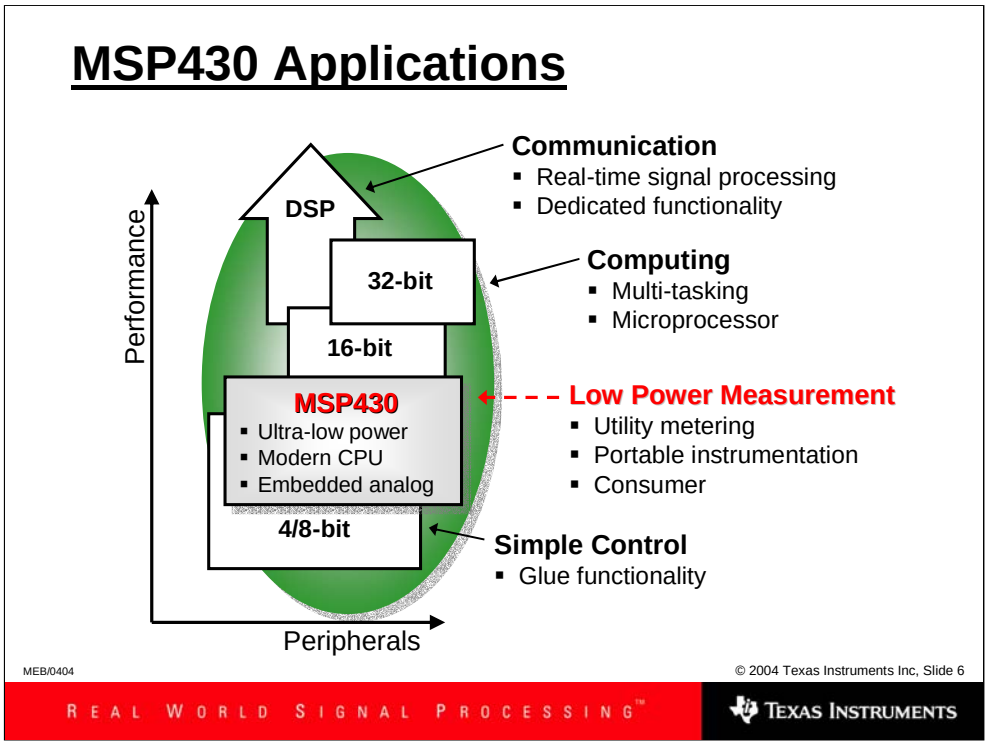


The example shows the effectiveness of the MSP430's 16-bit architecture in a common function, the process of servicing an integrated 10-bit ADC saving the conversion code to RAM.

•The MSP430 can move any 8 or 16-bit value from any memory location to any memory location in the entire address space in one instruction.

•The 8-bit MCU requires numerous instructions, and is forced to break the 10-bit ADC output into two bytes. The limitation of an accumulator based architecture is also shown with data always passing through the accumulator. The need to always pass data through the accumulator and being forced to change memory pages with the 8-bit MCU increases code size, reduces performance and increases power consumption.

•A question to ask is if whether your application manipulates data greater than 8-bits, i.e. 10-bit+ data converters.



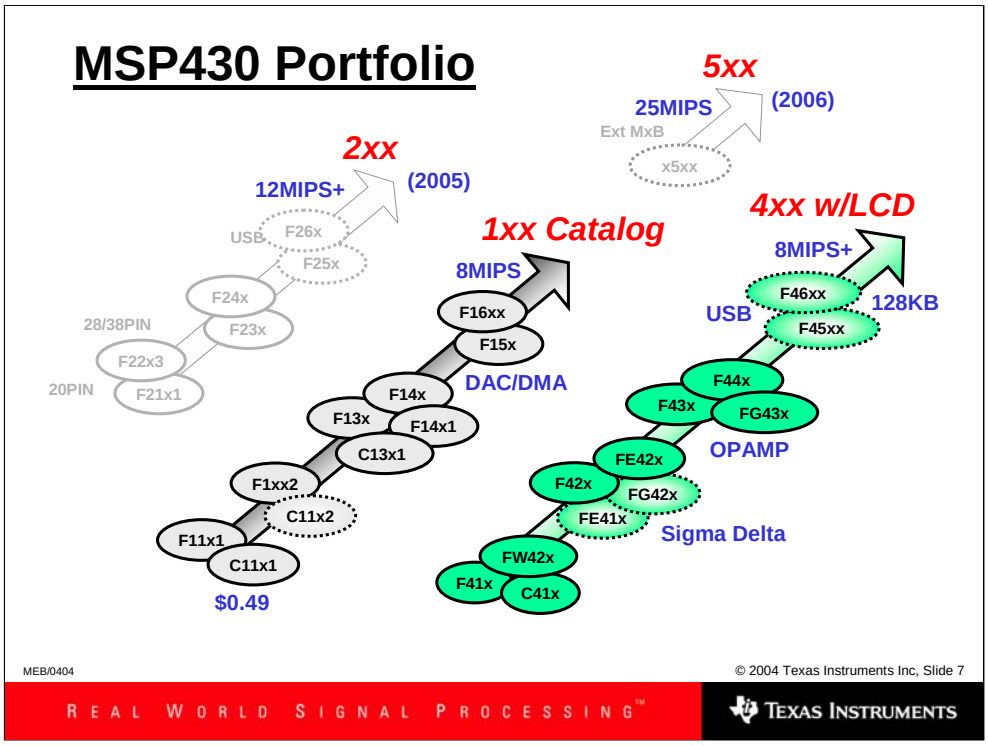
The features of the MSP430 family make the product ideal for battery-powered measurement applications.

Though the MSP430 is a 16-bit MCU, because of it's modern compact design, it provides solutions to many engineers across a wide variety of applications, primarily where 8-bit MCU's have been used before.

Utility Metering applications include gas, water, electricity, heat cost allocators, heat volume counters, etc.

Portable Instrumentation applications include personal blood glucose meters, blood pressure meters, heart rate monitor, thermometers, multi-meters, weight scales, portable accessories, etc.

Consumer applications include security systems, thermostats, smoke detectors, computer peripherals, cell phone accessories, etc.



3xx Family - AVAILABLE NOW – NOT SHOWN; The '3xx family was the first MSP430 family introduced in the late '90's. '3xx devices have an integrated LCD driver and are primarily used by customers in high-volume metering applications. The '3xx family operates from 2.5V – 5.5V at up to 3.3 MIPS. OTP and ROM '3xx devices are available – no Flash memory is available in the 3xx family and no new devices are planned.

1xx Family – AVAILABLE NOW; The '1xx family was introduced in 2000 to address requirements for a wide range of catalog applications. The '1xx family introduced the MSP430's ultra-low power Flash and is specified for operation at up to 8-MIPS and at voltages as low as 1.8V. The '1xx family spans a wide variety of devices from the entry level MSP430C1101 ROM device starting at $0.49, to highly integrated '16xx devices with up to 60kB of Flash, 12-bit ADC, 12-bit DAC, DMA controller, and up to 10K RAM. The '1xx members are in high-volume production and encouraged for new designs.

'4xx Family – AVAILABLE NOW; The '4xx complements the '1xx and adds an LCD driver. The' 4xx offers Flash memory, 8-MIPS and low voltage operation just as in '1xx. The '4xx family of Application Specific Standard Products introduce a high-resolution sigma-delta A-D converter, operational amplifiers, and other embedded analog functions ideal for single chip solutions. Many additional '4xx derivatives are planned with new peripherals. It is planned in the 4xx family to increase the memory range to 128KB and increase the system clock beyond 8MHz. The '4xx family is encouraged for new designs.

'2xx Family – AVAILABLE 2005; The 2xx will be introduced in 2005 as an upgrade path for existing '1xx users. The '2xx family will be pin and functionally compatible with '1xx devices offering even lower power, more speed, BOR on every device along with a variety of new peripherals. Additional '2xx information will be available fall 2004!

'5xx Family – AVAILBLE 2006; A series of MSP430s will be introduced in 2006 offering expanded memory, more speed and a variety of new peripherals. Additional '5xx information will be available fall 2005!

Why Is *Ultra-Low Power* Important?

- **Longer battery life**
- **Lower cost batteries**
- **Portable applications**
- ***Permanent* batteries reduce liability**
- **Reduced EMI simplifies PCB**
- **Simpler power supplies**

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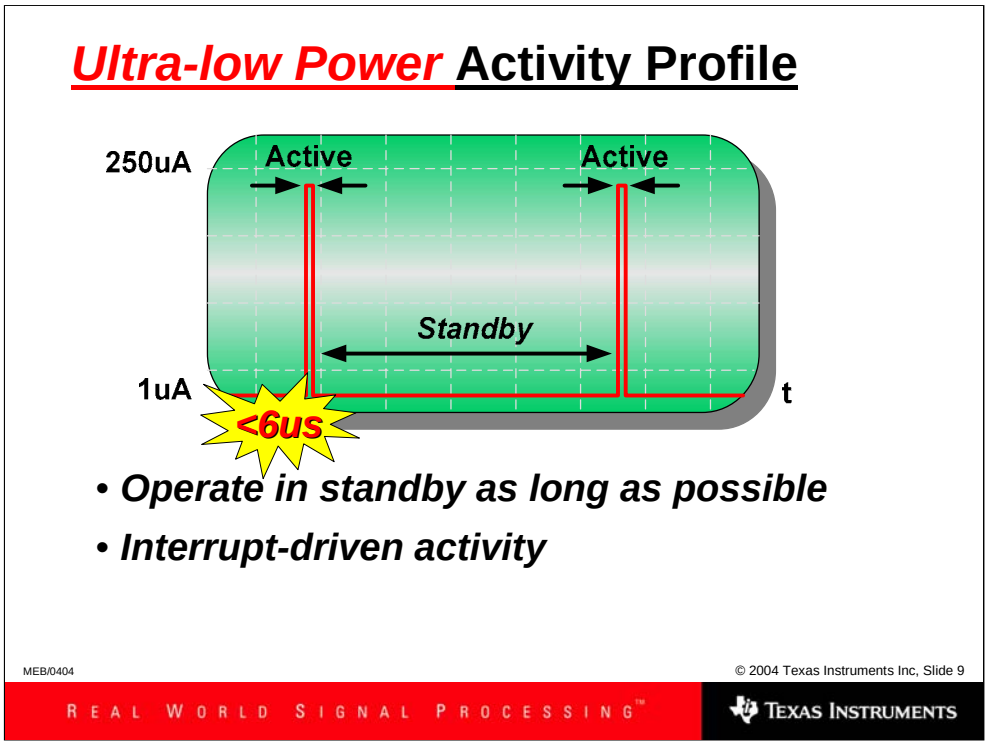
Is ultra-low power really important in all applications?

•The most apparent benefit for low-power is realized in battery powered applications. Reduced power consumption allows the use of smaller lower cost batteries.

•Another benefit in battery powered application is the concept of permanently installed batteries. The idea is to install sealed batteries at the factory that are not replaceable. With permanently sealed batteries in an application such as a portable medical device, replacement liability is eliminated. Cost is also reduced. With MSP430's ability to operate <1uA, it is very possible to develop product the operate from a single lithium battery for over 10-years.

•Generated EMI is very low because the MSP430 is so low power and can operate effectively at low-frequencies,.

•Even in application that have a power supply, low-power is an advantage. Smaller, lower cost power supplies can be used.

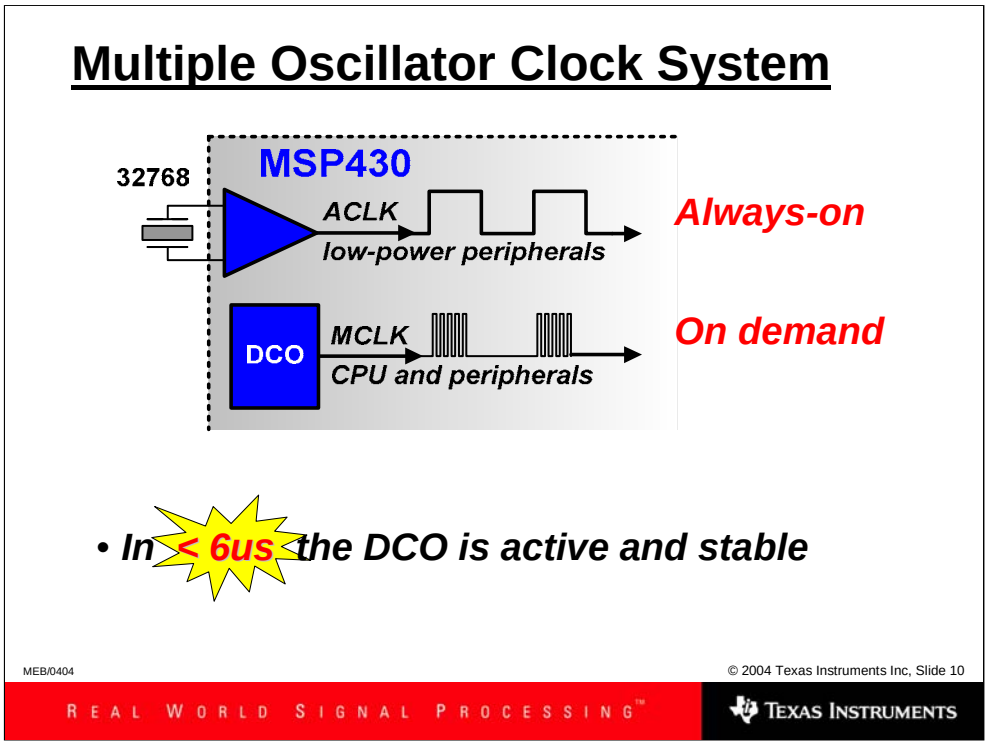


The MSP430 is designed specifically for battery-powered measurement applications.

•MSP430 ultra-low power solutions operate normally in standby mode in the 1uA range.

•To service interrupt driven events, the software efficiently uses the 16-bit RISC CPU's performance in very short, "burst" intervals. Transition from standby to full active is less than 6us. This results in a combination of ultra-low power consumption and very high-performance immediately when needed.

With the ultra-low power activity profile, the average system power consumption is the absolute lowest, without compromise in performance.



The MSP430 clock system is designed specifically for battery-powered measurement applications.

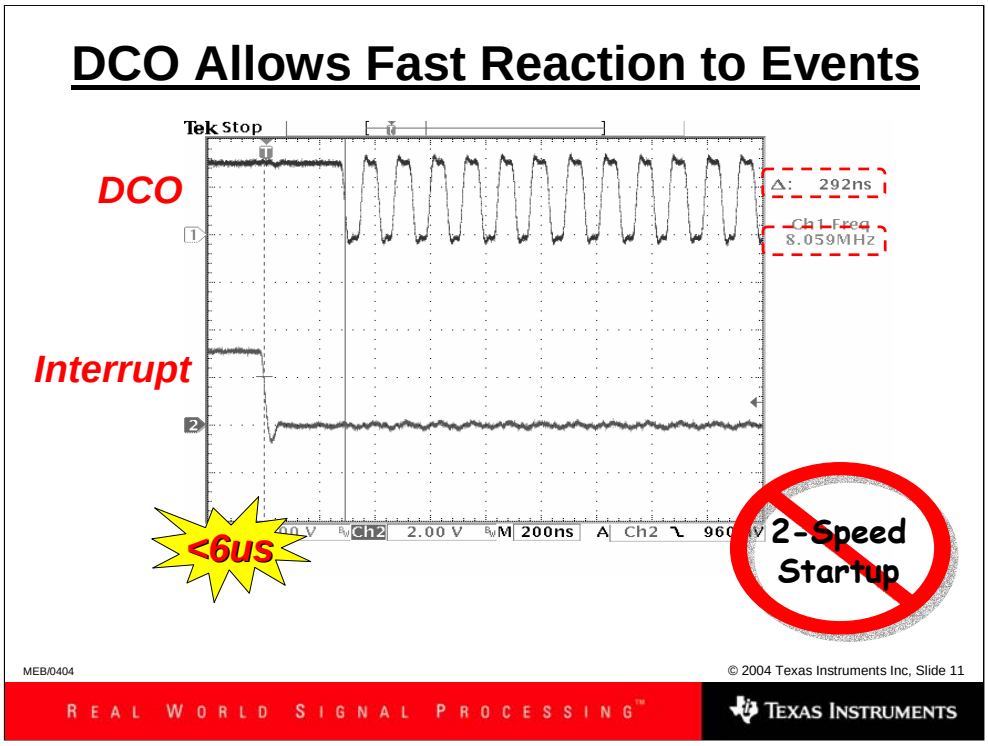
•Multiple oscillators are utilized to provide both an ultra-low power standby mode, and “on-demand” high-performance processing. The clock system is very flexible and allows the MSP430 to operate optimally from a single 32KHz crystal – with the internal digitally controlled oscillator (DCO) used for the CPU and high-speed peripherals.

•A low frequency Auxiliary Clock (ACLK) is driven directly from a common 32KHz watch crystal with no additional external components. The ACLK enables the MSP430’s ultra-low-power standby mode (LPM3) and an embedded real-time clock function. In LPM3, the MSP430 typically consumes 0.8uA.

•The integrated high-speed DCO can source the master clock (MCLK) used by the CPU and high-speed peripherals. By design, the DCO is active and fully stable in less than 6 µs no intermediate steps. This enables “instant on” high-performance processing – no long start-up for a second crystal or 2-speed start-up required. Because the DCO is digitally adjustable with software and hardware, stability over time and temperature are assured.

•To support non-low power applications, a high-speed crystal up to 8Mhz can also be used.

•It is also possible to operate the MSP430 with no crystal at all using just the internal DCO.

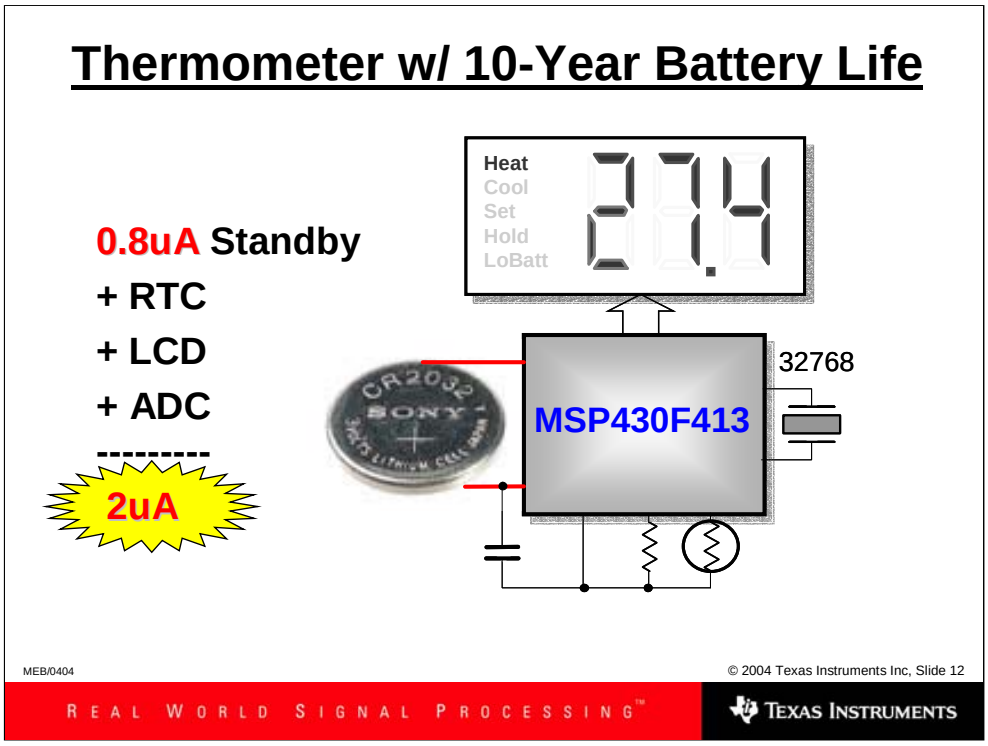


The screen capture shows the actual startup of an MSP430 DCO!

•In this example it can be seen that from an interrupt event the DCO is active and stable at 8MHz in well under 6us. In fact, in this example the measured DCO startup time is actually 292ns.

•With the MSP430, clock start up is “instant-on”. It is important that the high-speed DCO not only starts instantly, but also stabilizes instantly. Both instant-on and instant stability are important for features like asynchronous serial communication.

•With the MSP430 DCO, no delay or 2-speed clock startup occurs. The users application has instant access to the high-speed DCO from any operating mode.



A common application for MSP430 is a battery powered thermostat with display.

•The MSP430F413 system operates normally in standby mode LPM3 at ~0.8uA. When operating in LPM3, the watch-crystal oscillator (ACLK), a timer, the LCD driver and all interrupts are active.

•Once every second, the timer clocked by ACLK overflows and interrupts the CPU, which automatically starts the DCO. The CPU updates software based clock registers. Please keep in mind that when active, the CPU is operating from the fast DCO – not the slower ACLK. The update of the clock registers takes less than 100us.

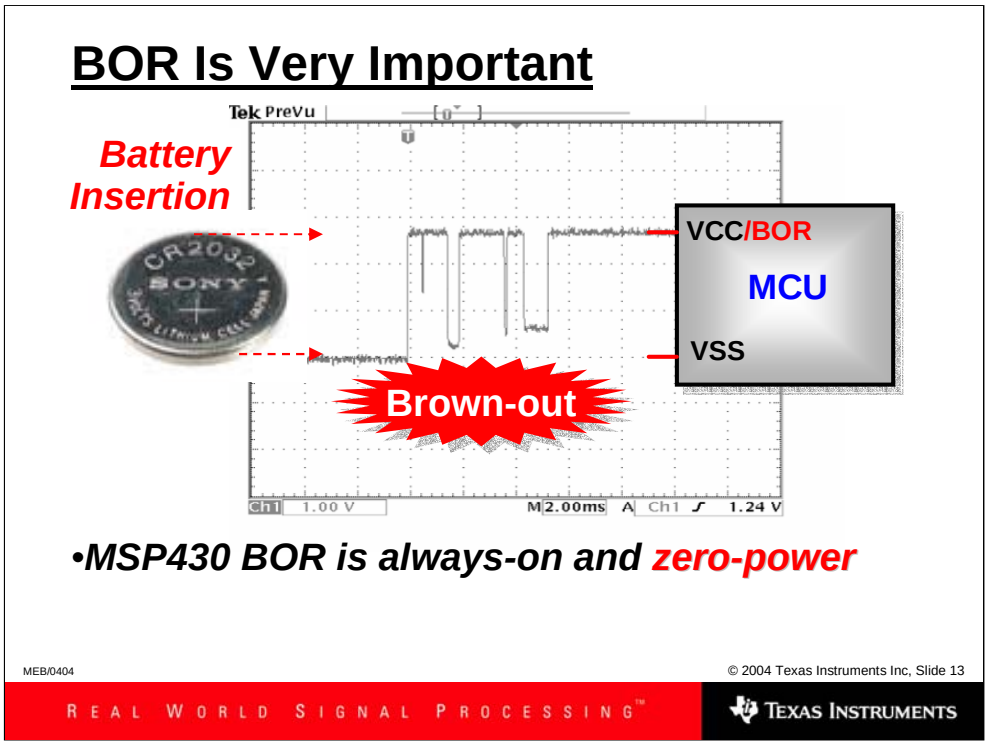
•Because the active duty cycle for the embedded real-time clock function is so low taking only about 100us every 1 second - 100/1000000 - the incremental current consumption is only 30nA.

•Every few seconds the MSP430F413 measures the resistance of a thermistor using an integrated precision slope ADC. The temperature is calculated and displayed. Because the ADC function occurs only every few seconds, the current impact is very low.

•Many other MSP430F413 resources are fully available for additional system features.

•The current consumption for the entire system including the MSP430, LCD and RTC and ADC function is only 2uA.

•Because of the entire system's ultra-low power consumption, the application can operate for 10-years from a common coin cell battery.



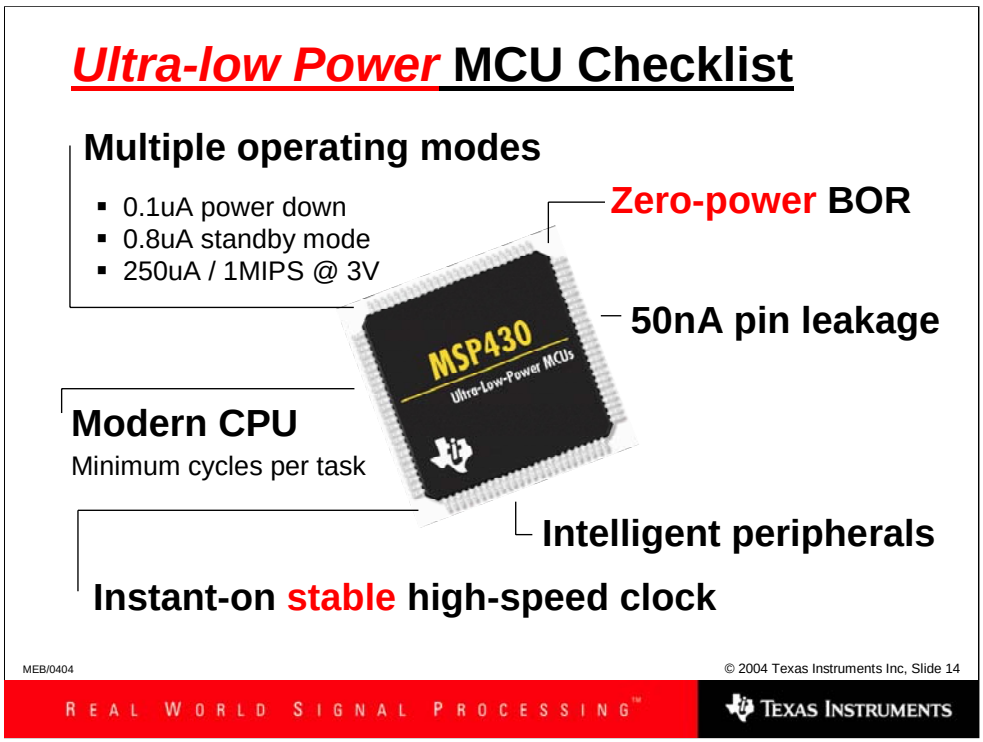
The MSP430 introduced the industry's first ultra-low power BOR protection feature.

•The brown-out reset (BOR) function forces a MCU into reset both on power-up when VCC rises and when VCC falls below normal operating range, but not fully to ground.

•While BOR protection is not unique, the MSP430 features a unique low-power implementation that is in the nA range. This makes BOR practical for all applications including those that are extremely low power. The MSP430 BOR function is so low power that it is always-on and active even in all low-power modes. This ensures the most reliable performance possible.

•Competitor's BOR protection is in the 10-50uA range, which is not usable in ultra-low power battery powered applications. This leaves the application vulnerable to BOR conditions.

•The screen shot shows a typical battery insertion and real example of brownout.



The MSP430 is designed specifically for battery-power measurement applications.

•The clock system allows many low-power modes with no compromise in performance.

•Because of a wide operating voltage range, the MSP430 can often be powered directly from a battery.

•The MSP430 BOR implementation is truly ultra-low power, in the nA range and practical for all applications. The MSP430 BOR function is so low power that this functions is always active, even in all low-power modes. This ensures the most reliable performance possible. Competitors BOR protection is in the uA range and not usable in ultra-low power battery powered applications, which leave the application vulnerable to BOR conditions.

•The port pins have very low leakage when connected to external inputs. This is very important as many MCU's have several uA of leakage on each port pin.

•The overall MSP430 architecture including a 16-bit CPU with 16 registers and 16-bit data and address buses minimize power consuming fetches to memory. A fast vectored-interrupt structure reduces the need for wasteful CPU software flag polling.

•Many intelligent hardware peripheral features are provided that allow tasks to be completed independent of the CPU and far more efficiently. These include the autoscan feature in the ADC12 and the available DMA. With the intelligent peripherals, the CPU does not need to be over clocked to deliver the required system performance.

MSP430x1xx Catalog Devices

Device	Pins	Max Flash	Max RAM	BOR	Features
MSP430x11x1	20	4KB	256B		As low as $0.49
MSP430F11x2	20	8KB	256B	✓	ADC10
MSP430F12x	28	8KB	256B		USART
MSP430F12x2	28	8KB	256B	✓	ADC10/USART
MSP430F13x	64	16KB	512B		ADC12/USART
MSP430F14x	64	60KB	2KB		F13x+(2)USART/MPY
MSP430F15x	64	32KB	1KB	✓	F13x+(2)DAC12/DMA/I2C
MSP430F16x	64	60KB	10KB	✓	F14x+ (2)DAC12/DMA/I2C

New!

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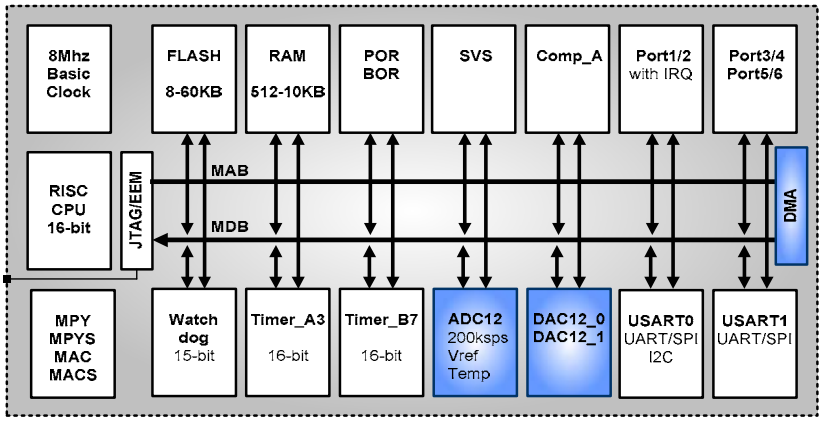
'1xx Family – AVAILABLE NOW - for a wide range of catalog applications.

•The '1xx family introduced the MSP430's ultra-low power Flash and is specified for operation at up to 8-MIPS and at voltages as low as 1.8V.

•The '1xx family spans a wide variety of devices from the entry level MSP430C1101 ROM device starting at $0.49, to highly integrated '16xx devices with up to 60kB of Flash, 12-bit ADC, 12-bit DAC and a DMA controller.

•The '1xx members are in high-volume production and encouraged for new designs.

‘F15x/16x Signal Chain on-Chip



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‘F15x/16x families are 100% pin compatible and are functional extensions of the ‘F14x/13x families.

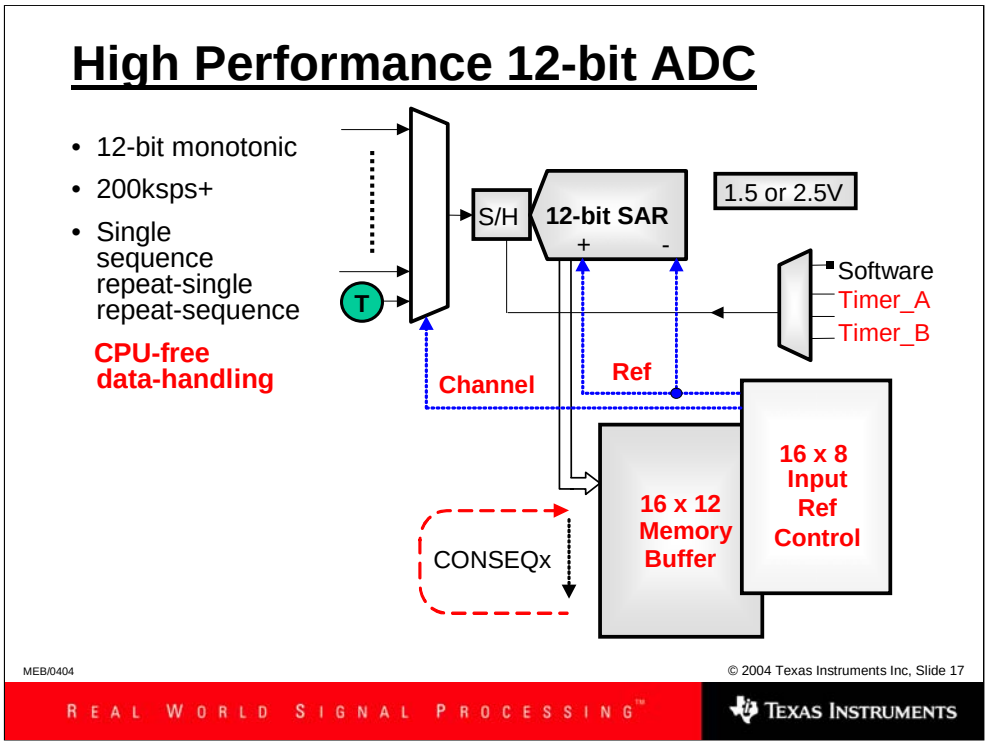
•Additional analog features are available that enable higher reliability, integration and performance.

•A programmable supply voltage supervisor is added for very accurate supply voltage monitoring. If the supply falls below a programmed level, the device can be configured to completely reset, preventing errant operation.

•Two 12-bit DAC’s generate independent analog outputs.

•The USART0 is enhanced to support full master/slave I2C operation in addition to the UART and SPI modes.

•A direct memory access controller (DMA) controller allows programmable and automatic data handling from any memory location to any memory location.



The ADC12 module supports fast, 12-bit analog-to-digital conversions.

The module implements a 12-bit SAR core, sample select control, reference generator and a 16 word conversion-and-control buffer. The conversion-and-control buffer allows up to 16 independent ADC samples to be converted and stored without any CPU intervention.

ADC12 features include:

•Greater than 200 ksps maximum conversion rate

•Monotonic 12-bit converter with no missing codes

•Sample-and-hold with programmable sampling periods controlled by software or timers

•Start of conversion initiation by software, Timer_A, or Timer_B

•Software selectable on-chip reference voltage generation (1.5 V or 2.5 V)

•Software selectable internal or external reference

•Eight individually configurable external input channels (twelve on MSP430FG43x devices)

•Conversion channels for internal temperature sensor, AVCC, and external references

•Independent channel-selectable reference sources for both positive and negative references

•Selectable conversion clock source

•Single-channel, repeat-single-channel, sequence, and repeat-sequence conversion modes

•Interrupt vector register for fast decoding of 18 ADC interrupts

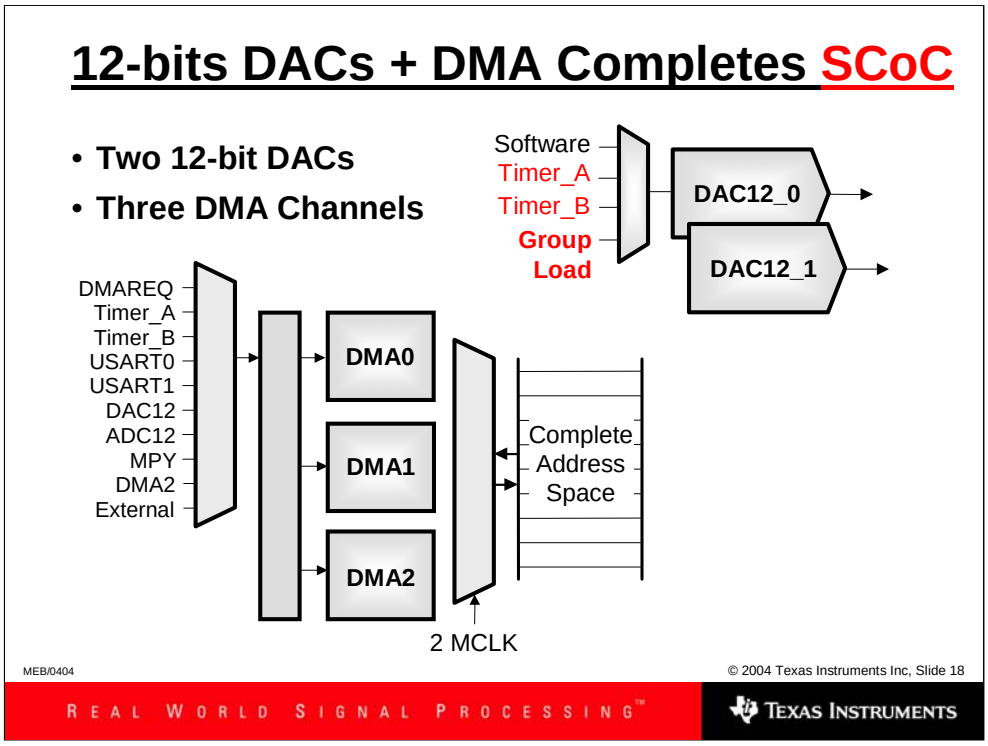
•16 conversion-result storage registers

The ADC12 offers several features to reduce CPU loading during high-speed conversions

•A sample start can be triggered using an output from timer_A or timer_B for a precise conversion start, independent of CPU activity.

•16 conversion memory buffers with individual control registers allow up to 16 ADC samples to be taken without any CPU intervention.

•Each conversion buffer can be configured selecting the input channel and reference.



The DAC12 module is a 12-bit, R-ladder, voltage output DAC.

•The DAC12 can be configured in 8- or 12-bit mode and may be used in conjunction with the DMA controller. Multiple DAC12 modules may be grouped together for synchronous update operation.

Features of the DAC12 include:

•12-bit monotonic output

•Programmable settling time vs power consumption

•Internal or external reference selection

•Straight binary or 2's compliment data format

•Self-calibration option for offset correction

•Multiple DAC12 modules can be grouped for simultaneous update

•8- or 12-bit voltage output resolution

The direct memory access (DMA) controller transfers data from one address to another without CPU intervention across the entire address range.

The DMA offers a significant performance boost relieving the CPU from basic data handling allowing more advanced applications at lower power and using less code.

The DMA controller features include:

•Three independent transfer channels

•Configurable DMA channel priorities

•Requires only two MCLK clock cycles

•Byte or word and mixed byte/word transfer capability

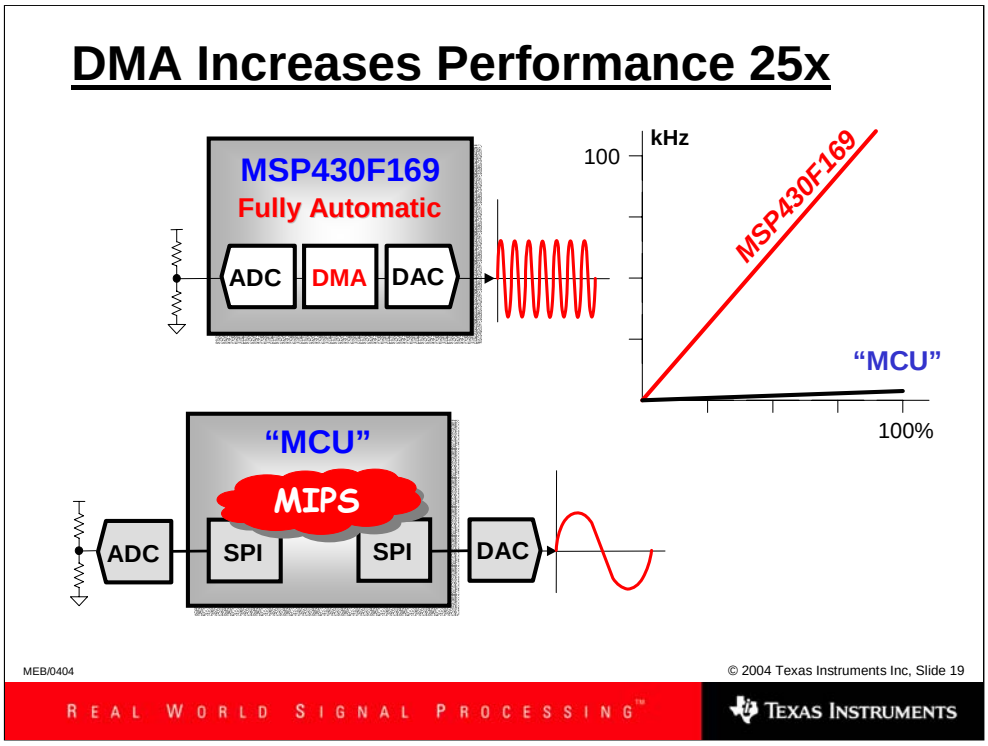
•Block sizes up to 65535 bytes or words

•Configurable transfer trigger selections

•Selectable edge or level-triggered transfer

•Four transfer-addressing modes

•Single, block, or burst-block transfer modes



The MSP430F16x is the first MCU family - complete "Signal Chain on Chip" one chip.

•The example shows an application that outputs a sine wave in response to a measured analog input. The sine wave has 32-steps. We will see that without SCoC, a typical MCU becomes overloaded and the system performance is very limited.

•The advantage of Signal-Chain-on-Chip is that the MCU does not have to spend resources handling data and managing serial interfaces between external data converters – instead the solution is all on one chip – and fully automatic! The DMA can automatically transfer data from the integrated data converters using only 2 bus clocks. This means with an 8MHz bus clock and a 32-step sine wave, that a 120kHz output is possible!

•Without DMA the typical software solution quickly becomes overloaded primarily managing the serial transfers between the external ADC and DAC. The DAC load ISR function alone required CPU 53 cycles which means at 32-steps, 1696 CPU bus cycles are required for each full sine wave. With a typical solution the sine wave output is limited to under 5kHz, and the CPU is fully loaded.

•With SCoC the performance of a system is dramatically increased and CPU resources are available for more advanced signal processing. This means that MSP430 applications can operate at lower clock speeds - reducing power consumption and EMI – and deliver higher performance.

MSP430x4xx w/ LCD Drivers

Device	Pins	Max Flash	Max RAM	LCD	Features
MSP430F41x	64	32KB	1KB	96	< $2
MSP430F42x	64	32KB	1KB	128	SD16/USART
MSP430FW42x	64	32KB	1KB	96	Scan I/F Flow Meter
MSP430FE42x	64	32KB	1KB	128	ESP430 E-meter/USART
MSP430F43x	80	32KB	1KB	128	ADC12/USART
MSP430FG43x	80	60KB	2KB	128	F43x+(2)DAC12/DMA/OA
MSP430F44x	100	60KB	2KB	160	F43x+(2)USART/MPY

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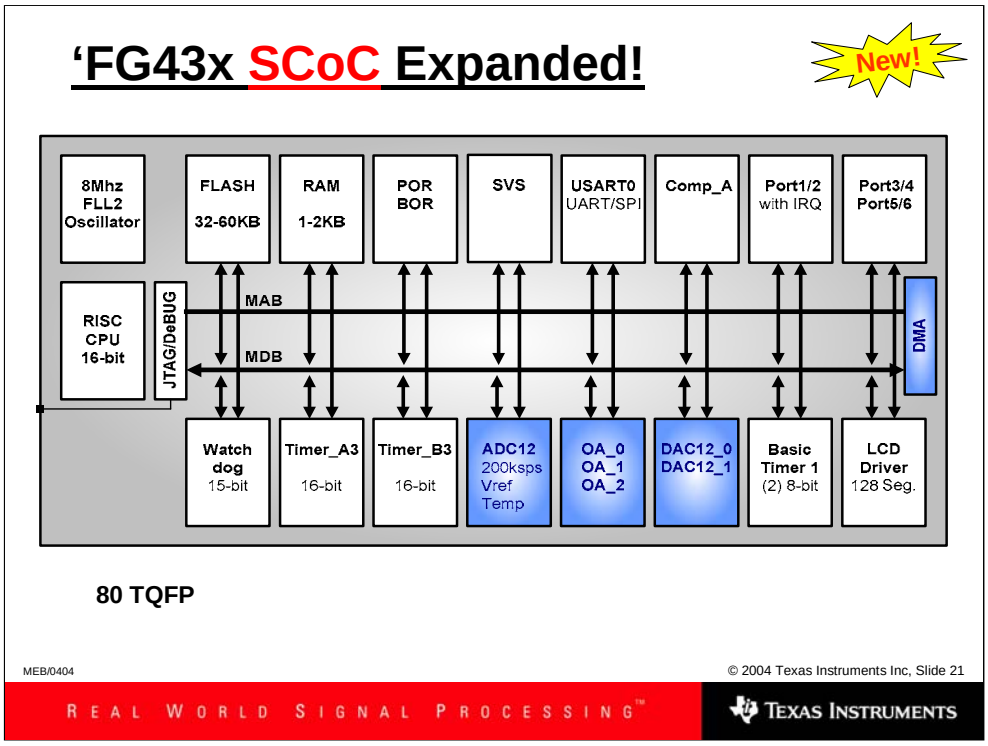
'4xx Family – AVAILABLE NOW - complements the '1xx and adds an LCD driver.

•The' 4xx offers Flash memory, 8-MIPS and low voltage operation just as in '1xx.

•The '4xx family of Application Specific Standard Products introduce a high-resolution sigma-delta A-D converter, operational amplifiers, and other embedded analog functions ideal for single chip solutions.

•Many additional '4xx derivative are planned with new peripherals. The '4xx family is encouraged for new designs.



The 'FG43x are the newest and most integrated member of the MSP430 family with a level of mixed signal integration that allows a complete Signal-Chain-on –Chip,"SCoC".

•Like all '1xx/4xx devices, the 'FG43x operates from 1.8 - 3.6v at up to 8MIPS. Memory options for the 'FG43x range from 32KB – 60KB Flash.

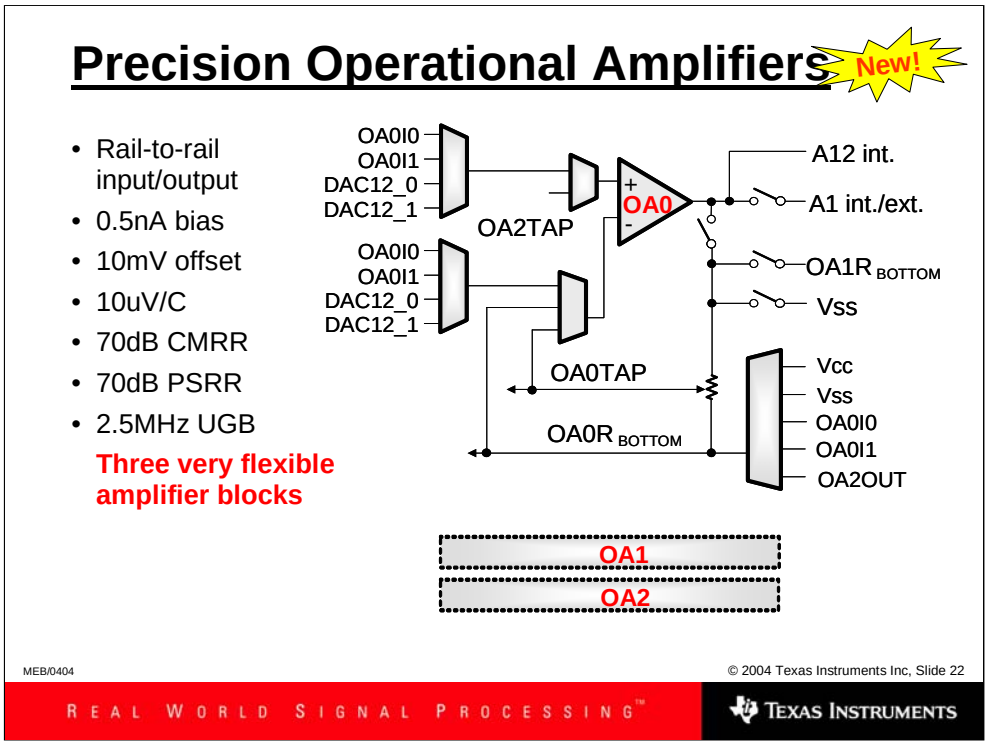
•Like all '4xx devices, the 'FG implements a Frequency-Locked-Loop (FLL) clock system. The FLL automatically stabilizes the DCO to a multiple of the 32kHz ACLK. This automatically stabilizes the DCO over temperature and voltage with no software intervention. The watch-crystal oscillator of the '4xx series is also improved and allows operation in LPM3 below 1uA extending battery life to the maximum!

•Like all '4xx devices, the 'FG43x also integrates a basic timer and LCD driver. The LCD driver on the 'FG43x can directly drive a segment-type LCD up to 128 segments.

•These higher-end devices offer many features including 5 general purpose I/O ports, ADC12, comparator_A, timer_A, timer_B, supply voltage supervisor and one USARTs.

•New on the 'FG43x are two 12-bit DACs that can generate independent analog outputs and three operational amplifiers.

•A direct memory access controller (DMA) controller allows programmable and automatic data handling from any memory location to any memory location.



The new OA op amps on the MSP430FG43x support front-end analog signal conditioning prior to analog-to- digital conversion.

Features of the OA include:

•Single supply, low-current operation

•Rail-to-rail output

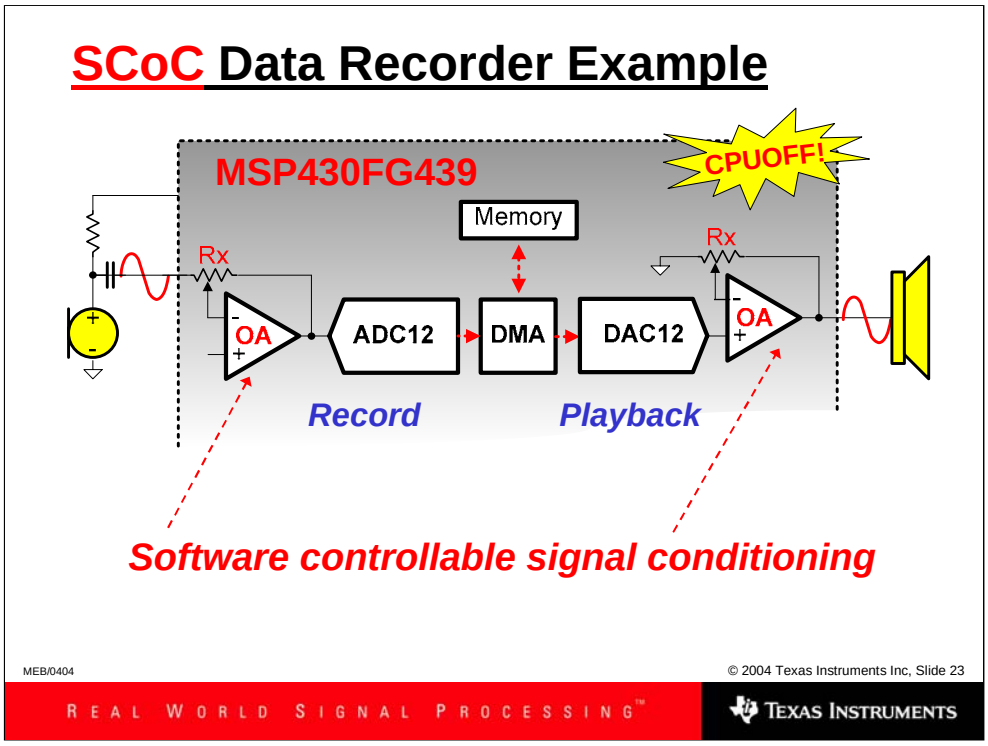
•Software selectable Rail-to-Rail input

•Programmable settling time vs. power consumption

•Software selectable configurations

•Software selectable feedback resistor ladder for PGA implementations

Because the are three op amps integrated in the MSP430FG43x, the amplifiers can be combined to create user-defined analog functions such as differential and programmable gain amplifiers.

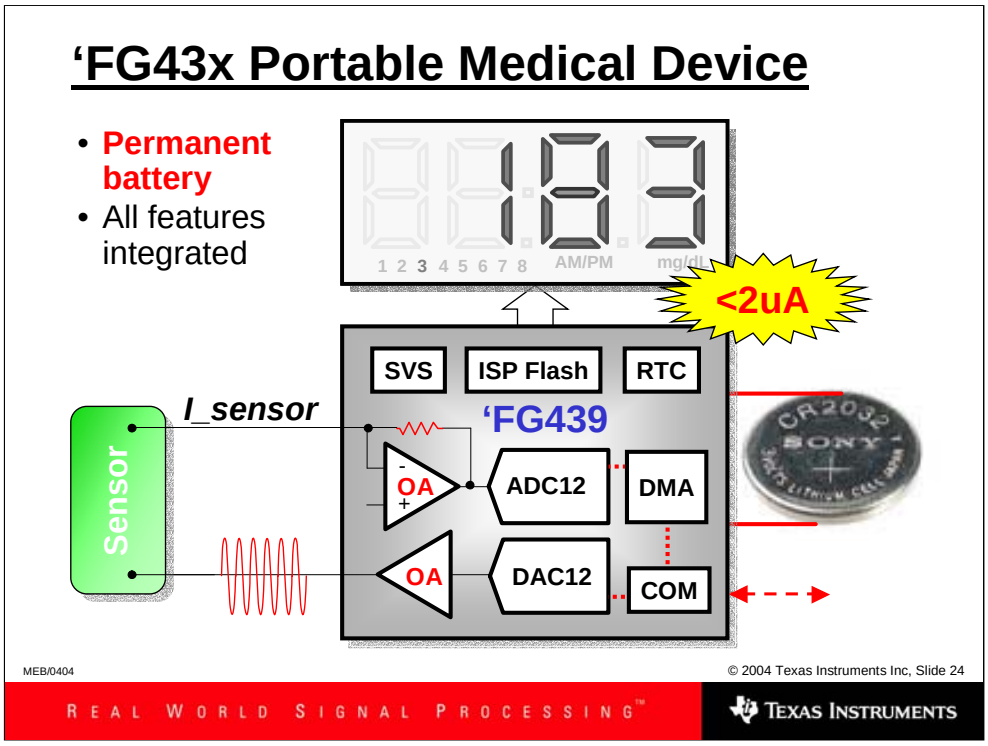


The example msp430dayII_vr.c shows how to implement a "voice recorder" with the MSP430FG439 Retro watch.

•When the push button on P2.1 is pressed a recording is made. The OP0 is used to interface to an external microphone. The output of OP0 is sampled by the ADC12 and the DMA transfers the voice samples to Flash.

•When the push button on P2.2 is pressed the playback mode is selected. The DMA0 is used to playback the recorded data using the DAC12. An external amplifier and speaker will be required.

•The demonstration is just for fun, with no attempt at voice compression so only a few second of speech can be recorded.



The example shows a MSP430FG43x application, a portable medical device

•The instrument requires the very lowest power and highest precision at the lowest possible total system cost. The MSP430’s ultra-low power and highly-integrated of the ‘FG43x make it perfect for such applications.

•The ‘FG439 operates normally in LPM3 - at ~ 1uA - running an embedded real-time clock function. The static LCD is always on, and consumes an additional ~ 0.8uA. In total, the application runs normally in standby under 2uA! A glucose measurement is made 4 – 6 times a day and lasts less than 1 minute. This means that the active duty cycle is very low, and has little effect on the total current consumption. The total system standby current of ~2uA will allow the instrument to operate from a common CR2032 220mAh battery for over 10years!

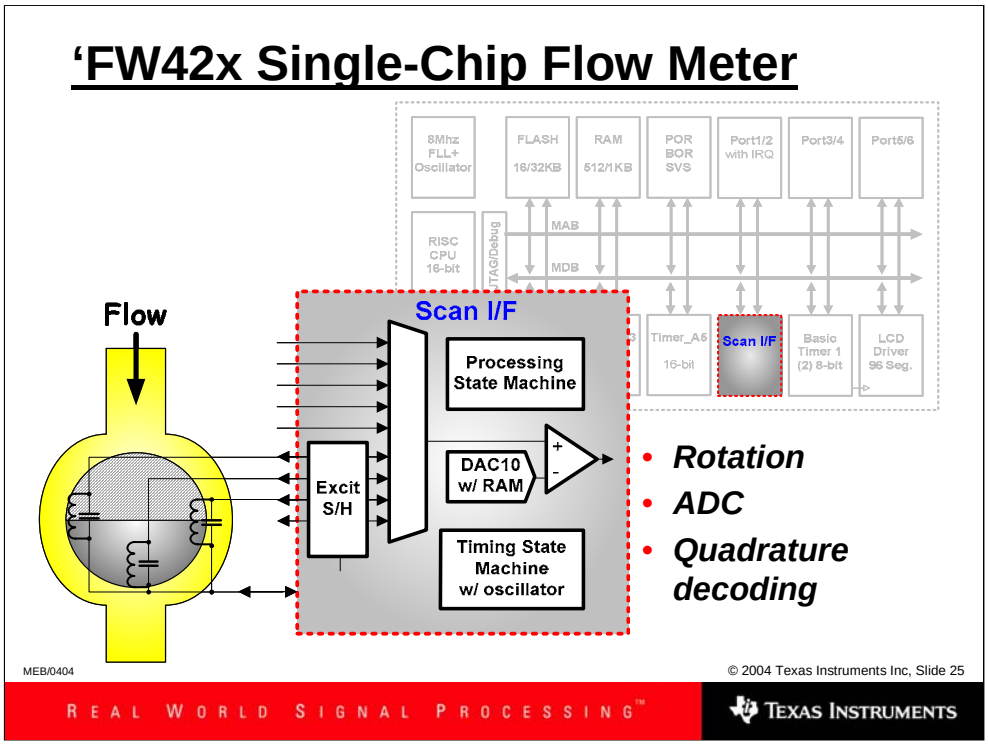
•Using the MSP430 the instrument can be sealed permanently with the original batteries installed during manufacturing and still provide 10 years of continuous operation.

•The internal OPA is used to convert a very small current output from the test strip to a voltage. This OPA is shut down for power management when not used – this is very important for maximum battery life! The voltage output of the OPA is measured by the ‘FG439’s internal 12-bit ADC12. The ADC12 also has an internal temperature sensor - this is used to measure the local temperature which is important in determining the glucose level. The glucose level is calculated and displayed on the LCD.

•An external RTC chip is not required since this in an embedded function in the MSP430.

•Only a single 32kHz crystal is required. The DCO generates the high-speed clock required for the CPU and other peripherals such as the UART.

•Since the MSP430’s Flash is in-system programmable, a portion of the Flash can be used to data-log the patients glucose measurements.



The 'FW42x is a family of 'F4xx devices specifically designed for battery-powered flow meter applications.

The example shows an ultra-low power water meter implementation.

The Scan IF module is used to automatically measure linear or rotational motion with the lowest possible power consumption.

•The Scan IF consists of three blocks: the analog front end (AFE), the processing state machine (PSM), and the timing state machine (TSM).

•The analog front end stimulates the sensors, senses the signal levels and converts them into their digital representation.

•The digital signals are passed into the processing state machine.

•The processing state machine is used to analyze and count rotation or motion. The timing state machine controls the analog front end, the processing state machine, and sets the timing.

The Scan IF features include:

•Support for different types of LC sensors

•Measurement of sensor signal envelope

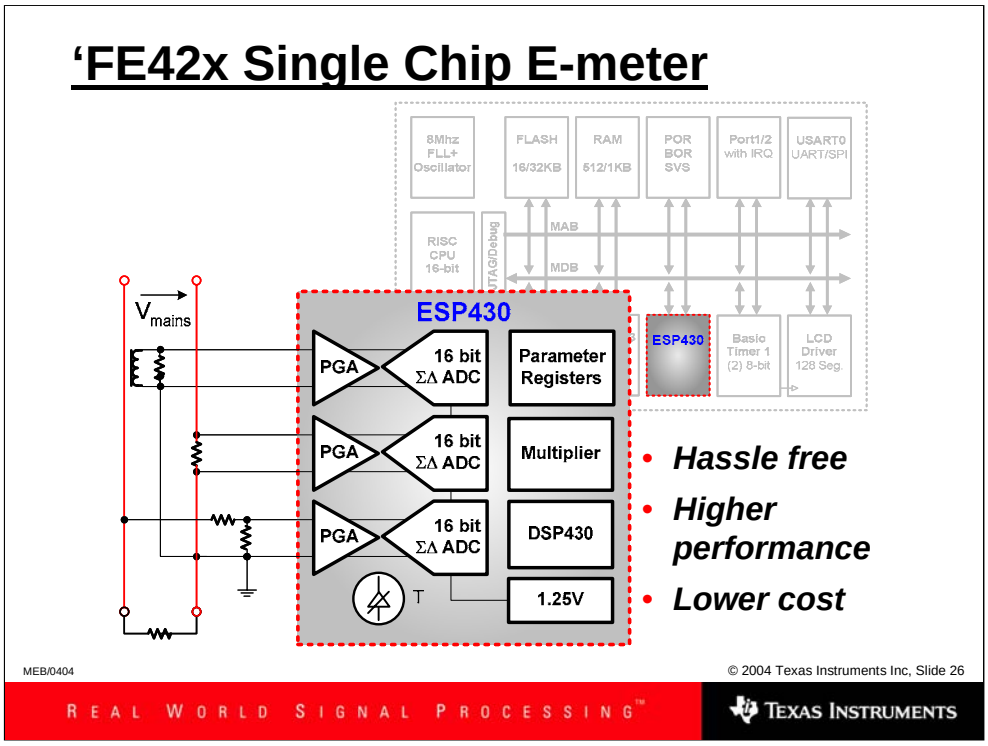
•Measurement of sensor signal oscillation amplitude

•Support for resistive sensors such as Hall-effect or giant magneto-resistive (GMR) sensors

•Direct analog input for A/D conversion

•Direct digital input for digital sensors such as optical decoders

•Support for quadrature decoding



The MSP430FE42x family introduced the industry's first single chip electricity meter.

•All components for a single phase e-meter are integrated in the 'FE42x family, including an embedded signal processor (ESP) metrology function.

•By combining an industry-standard ultra-low-power Flash MCU with an integrated high-performance analog front-end embedded signal processor (ESP) on a single-chip, the new MSP430FE42x family of products reduces the total system chip count by eighty percent, improving performance and reliability, while reducing cost and time to market when compared to first generation electronic solutions.

•Having critical energy calculations managed completely by ESP430CE1 frees the MCU functions for users to implement differentiated meter features such as display and automated meter reading (AMR).

The ESP430 integrated in the MSP430FE42x provides compete functionality for a hassle free single-phase e-meter solution.

•To provide the highest possible performance and simplify system design, the ESP430CE1 is a complete encapsulated single phase e-meter module. Three independent 16-bit sigma-delta ADCs, programmable gain amplifiers, a temperature sensor and a precision voltage reference under the control of a dedicated DSP430 are all integrated to perform the energy metrology function.

•The converted line voltage and current signals are digitally processed, providing energy and line period measurement; negative power flow indication; peak voltage and current; and phase and line-to-neutral current comparisons for tamper detection.

•With precise phase matching between current and voltage channels, the ESP performs the necessary calculations to supply accurate active energy, apparent energy, RMS voltage, current and waveform samples. The ESP provides a 0.1% accurate energy measurement over a dynamic current range of 1000 to 1, greatly surpassing the 1 percent accuracy common in typical mechanical meters.

The Retro-style watch is our gift to you as thanks for attending the seminar.

First Startup:

When initially powered, the device will display the default time: 12:00:00. It will immediately begin counting the seconds.

Normal Operation:

Setting the Time (Minutes): Press and hold SW1, pressing SW2 now increments the minute value.

Setting the Time (Hours): Press and hold SW2, pressing SW1 now increments the hour value.

Note: When pressing SW2, the device will first appear to change the unit mode. This is ignored by the watch after SW1 is pressed.

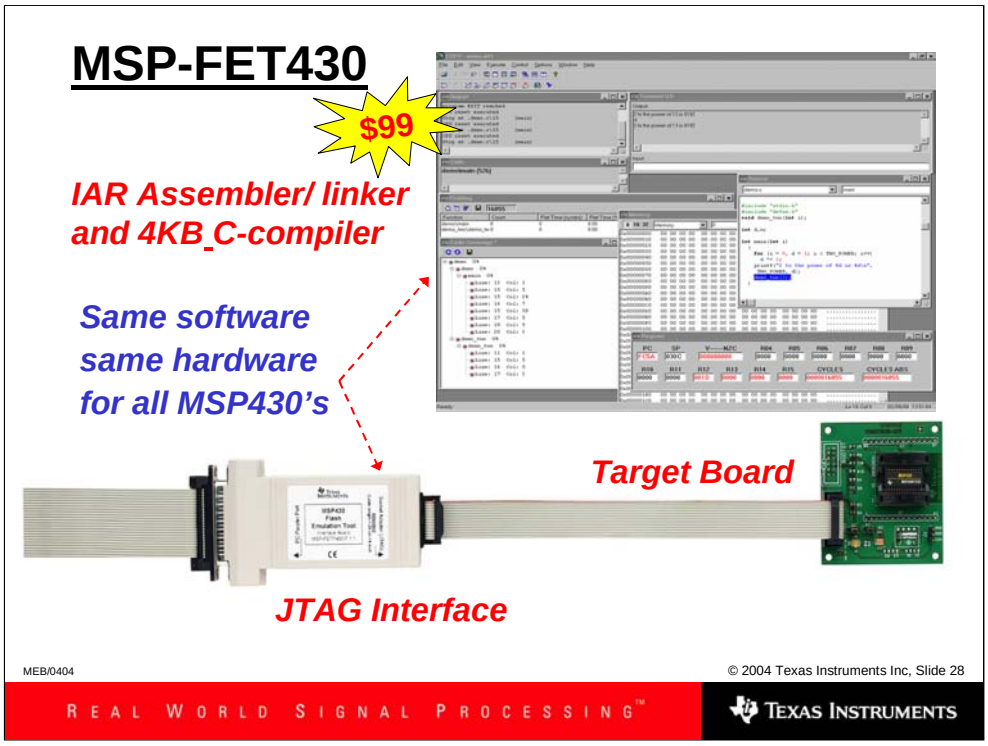
Displaying the Temperature: Press SW1, watch will return to clock mode after 6 seconds

Changing the unit Mode: Press SW2

Switching off LCD: Press SW1 (to enter Temperature mode) Press SW1 again. The LCD will turn on after 5 seconds.

Note: while LCD is off, device is in "low-power clock" mode and not in temperature mode.

Erasing Calibration Values: Press and hold SW2 until the temperature is displayed. While temperature is displayed, SW2 increases the displayed value and SW1 decreases the displayed value. Holding SW1 and SW2 simultaneously for 1 second saves the calibrated value.



Embedded Emulation with the MSP430. A common user software and physical interface is used for all MSP430s. This means only one tool needs to be learned.

•Today's applications operating at lower voltages, with tighter packaging and with higher-precision analog benefit greatly from the MSP430's modern in-system emulation approach. The MSP430's dedicated embedded emulation logic resides on the actual device itself and is accessed via industry standard JTAG using no additional system resources.

•From the first day of development, firmware engineers can now unobtrusively develop and debug their embedded application code with full-speed execution, breakpoints, and single-steps in their application.

• Embedded emulation becomes even more important with high-performance mixed-signal systems that must maintain the integrity of microvolt analog signals. Signal integrity is virtually impossible with cumbersome in-circuit emulators that are sensitive to cabling crosstalk.

•The Flash Emulation Tool – or FET – is a complete JTAG based, real-time in-system emulation, Integrated Development Environment (IDE).

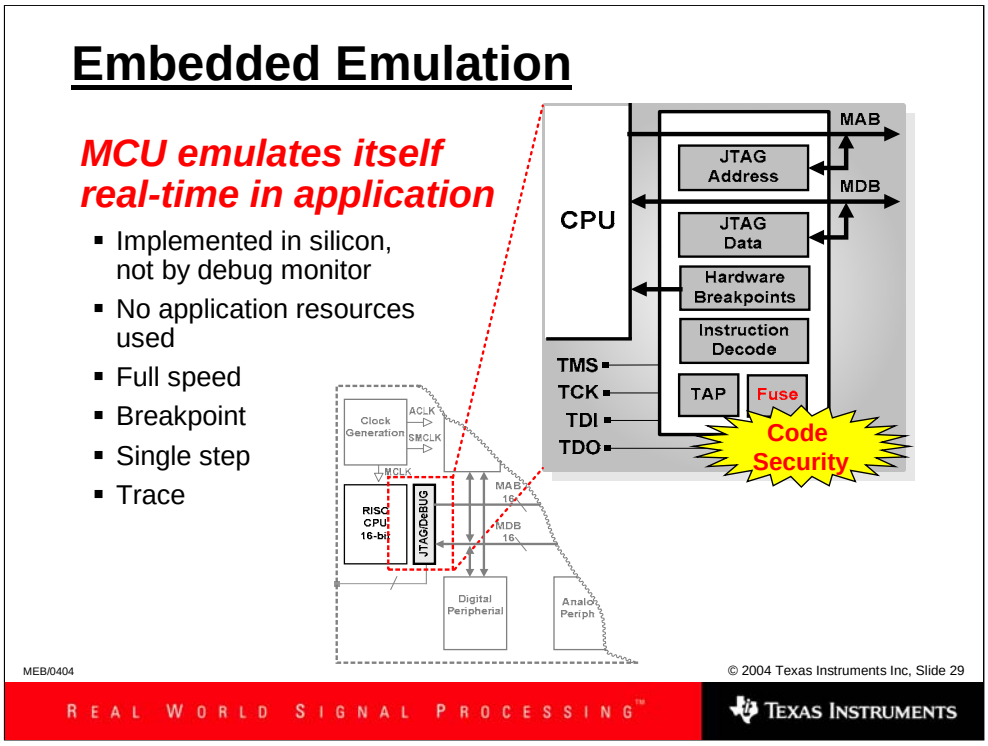
•The FET comes with a target board, two device samples, a JTAG interface box, cables and all documentation on a CD-ROM.

•A CD-ROM includes the IAR Kickstart IDE, assembler, linker, simulator and 4kB C-compiler.

•The FET now also includes evaluation version of the Quadrovox and Rowley IDE's!

•The FET supports complete in-system development and is available for all MSP430F1xx and MSP430F4xx Flash devices. Programming, assembler/C-source level debug, single stepping, multiple hardware breakpoints, full-speed operation and peripheral access are all fully supported in-system using JTAG.

•The FET comes complete with everything required to complete an entire project!



Embedded Emulation with the MSP430

•Development is in-system and subject to the exact same characteristics of the final application

•Non-obtrusive especially in portable and high-pin count situations

•Common user software and physical interface

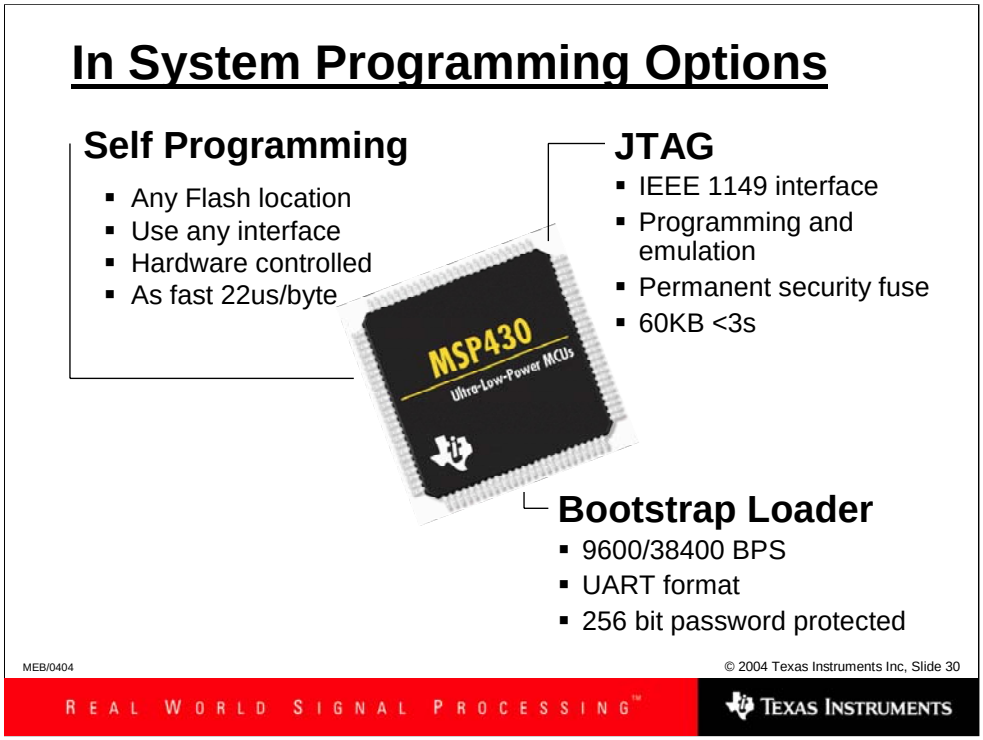
•Today's applications operating at lower voltages, with tighter packaging and higher-precision analog, benefit greatly from the MSP430's in-system emulation approach. The MSP430's dedicated embedded emulation logic resides on the actual device itself and is accessed via industry standard JTAG using no additional system resources.

•From the first day of development, firmware engineers can now unobtrusively develop and debug their embedded code with full-speed execution, breakpoints, and single steps in an application.

•Embedded emulation becomes even more important with high performance mixed-signal systems that must maintain the integrity of microvolt analog signals. Signal integrity is virtually impossible with cumbersome in-circuit emulators that are sensitive to cabling crosstalk. And unlike abstract background debuggers, no time-sharing of system serial communication resources is required with embedded emulation on the MSP430.

•By combining the flexibility of in-system programmable Flash memory, unobtrusive embedded emulation, and a common user interface, development time is reduced. And, should the situation arise, last minute code updates as well as remote scheduled and unscheduled upgrades can also be made.

•Access to the JTAG port can be permanently disabled using a non-erasable fuse.



The Flash memory of the MSP430 can be programmed very fast using several different methods.

•The Flash is segmented into 512B main memory segments with two additional 128B information memory segments. The only difference between main and information memory is size – code and data can be located anywhere. The total number of main memory segments depends on the device - for example, a 4KB device has eight main memory segments.

•Flash memory operates from 1.8V – 3.6V, but at least 2.7V must be present during programming or erasing. Flash can be erased and reprogrammed 100k times with 100 year data retention typical. Because of an advanced design, 60kB of Flash can be programmed in as fast as 2 seconds. For security reasons, Flash can not be programmed or erased unless a password is used when the Flash control registers are accessed.

•There are three methods of programming Flash; Out or in-system using JTAG, a Bootstrap Loader (BSL) or in system using normal software.

•The Flash Emulation Tool (FET) from TI, the MSP430-GANG430 programmer from TI, and many third parties offer MSP430-JTAG programmers. You can even build your own JTAG programmer – an application report is available at www.ti.com/msp430.

•The bootstrap loader is a section of ROM code that resides on the device itself and allows communication using a common 9600 baud UART protocol. Information regarding the BSL is also available on the MSP430 website.

•The time to program any bit, byte or word is 35/f(FTG) – where FTG is between 257kHz – 476kHz. This means that the programming time for any bit, byte or word is as fast as 74us. If memory are programmed sequentially, the programming time can be reduced to 42us.

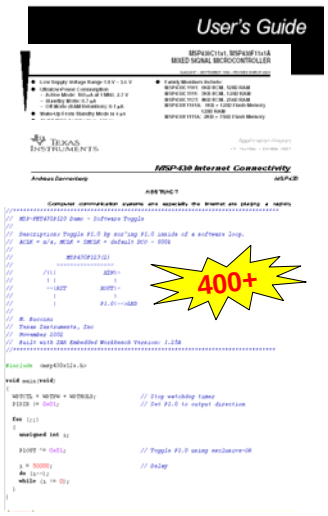
•Because Flash is so easy to program in system, in many cases it can be used to replace an external EEPROM for non-volatile storage.

Support

MSP430x1xx Family

New!

- **User's Guide**
  Architecture and peripheral info
- **Datasheets**
  Electrical, packaging and pinning
- **Application reports**
  Complete design examples
- **Code examples**
  Downloadable code



www.ti.com/msp430

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The 430 is very well supported including a dedicated TI website www.ti.com/msp430.

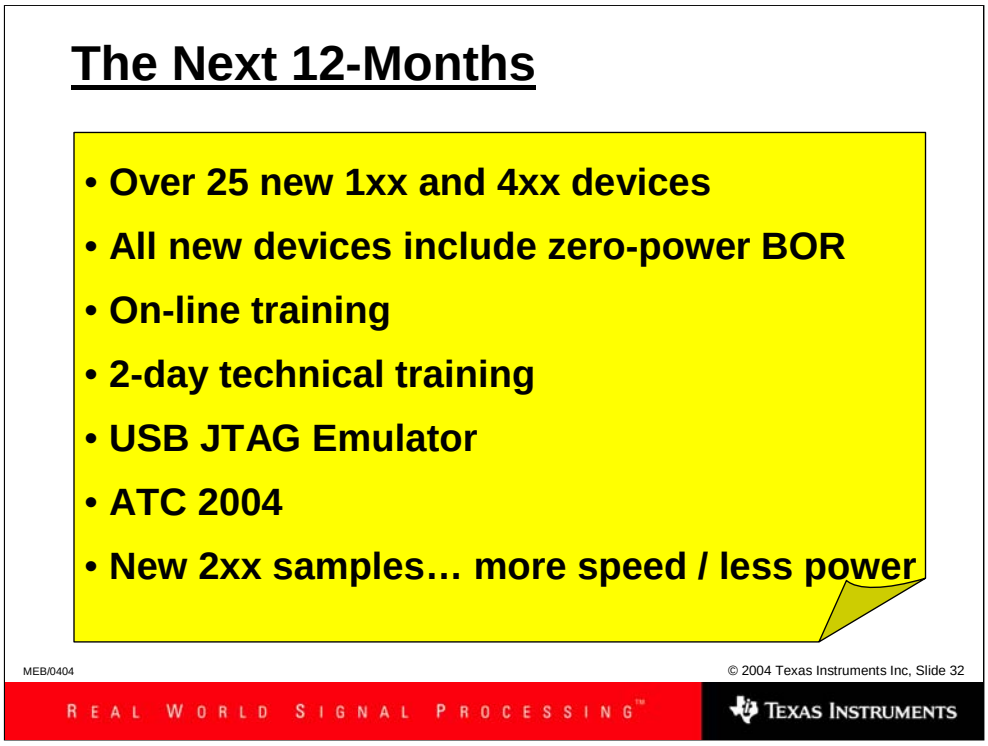
•The most current MSP430 documentation is available at our all new MSP430 website

•For detailed technical information on device families, TI has just updated the MSP430x1xx and MSP430x4xx User's Guide.

•Chip specific electrical and pin information is available in device-specific datasheets.

•Over 75 application reports and 400+ downloadable code examples are available from the MSP430 website.

•An FAQ system (Knowledge Base) and regional technical support phone lines also are available.


The Next 12-Months
• Over 25 new 1xx and 4xx devices
• All new devices include zero-power BOR
• On-line training
• 2-day technical training
• USB JTAG Emulator
• ATC 2004
• New 2xx samples… more speed / less power
MEB/0404
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REAL WORLD SIGNAL PROCESSING™
TEXAS INSTRUMENTS

There is a lot coming for the MSP430 in the next 12 months

•TI will introduce over 30 new derivative of the 1xx and 4xx families. Both of these families are strongly encouraged for new designs.

•There are many short and informative on-line training sessions available on the MSP430 website.

•To support developers new to the MSP430 wanting to jump-start their projects, a 2-day professional training course is planned. The course will be taught by TI experts at TI training facilities around the world.

•A USB based MSP430 Flash emulation tool will be available Q4-2004.

•The third annual TI MSP430 advanced technical conference will be offered again this year for experience MSP430 developers. The conference will be offered in Dallas, Germany and Asia. The conferences will be in 4Q-2004.

•The next generation MSP430x2xx will be announced at the end of the year. Please stay tuned for more information Q4-2004.

It is time to change to the MSP430 - the Mixed Signal Processor ideal for battery-powered measurement applications.

Use Less Power; The MSP430 architecture is designed specifically for ultra-low power applications – specific operating modes are implemented to reduced power consumption and dramatically extend battery life. The combined effect of all of the MSP430 features that are by design optimized for ultra-low power will enable your application to use the absolute minimum power consumption.

Write Less Code; The MSP430 16-bit, ultra-low power CPU has more effective processing throughput, is smaller in size, and more code-efficient than other 8/16-bit microcontrollers. When using the MSP430, this results in programmers writing less lines of code. **Now it's possible to develop ultra-low power, high-performance applications at a fraction of the code size previously possible.**

Get to Market Faster; The MSP430's IDE is really easy to use. A Flash MSP430 is developed in the actual application with the actual application running. No monitor or background debugger is used. The debug logic is on-chip and dedicated for only debug accessed with JTAG. An extensive array of collateral is available and TI and distributor FAEs are always available to answer your questions.

Embedded analog peripherals including ADC's, comparators, DAC's, LCD drivers and supply voltage supervisors are available to support precision measurement. These peripherals enable better products to be built using fewer chips.

The Perfect Fit; Over 100 MSP430 fully compatible derivatives are available today from the entry-level $0.49 20-pin MSP430F1101 to the very highly integrated MSP430FG439 signal chain on chip. Just the right device is available for a wide variety of applications. An extensive road-map of fully compatible new devices are underway that are even lower power, more integrated and with better performance to meet your requirements in future.

MSP430Day II FAQ

- **Can I get a copy of this presentation?**
  Yes at **www.ti.com/msp430**
- **Can I develop with the 4-30 day retro watch?**
  Yes, you just need an MSP430 JTAG interface available with any TI MSP-FET430Pxxx or available from third parties at **www.ti.com/msp430**
- **Where can I get the LCD on the retro watch?**
  www.softbaugh.com part number SBLCDA4
- **When did TI get in the MCU business?**
  In 1972 TI invented the MCU with the TMS1000 and has shipped billions and billions and billions of units!

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This slide provides MSP-430-Day-II Common Questions

Thanks For Attending!

- **50% TI MSP430 Tool Discount**
  - MSP-FET430P120
  - MSP-FET430P140
  - MSP-FET430P410
  - MSP-FET430P430
  - MSP-FET430P440
- **Coupon Code: CMPFT430**
- **This offer is valid only valid through Ti's eStore @ www.ti.com through May 31, 2004**

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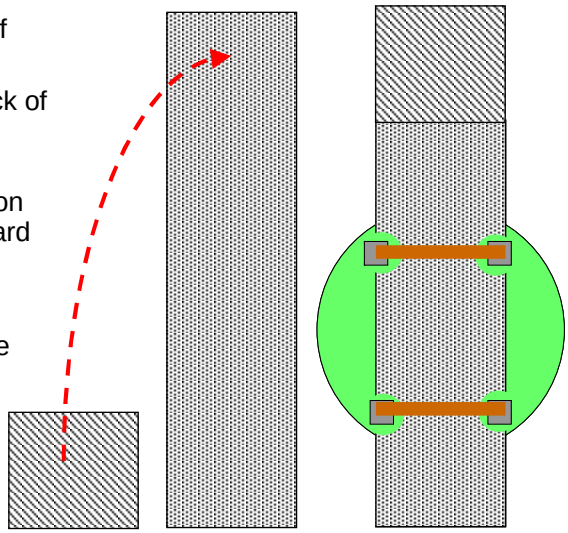
The slide provides the details for TI's special MSP430 FET development tool discount offer

Attaching The Retro Watch Strap

1. Peel adhesive cover off the back of 2” strap
2. Affix 2” strap to the back of 10” strap so that both strap ends are aligned
3. Place combined strap on back of retro watch board
4. Cut holes in strap to expose solder pads
5. Solder 22G copper wire across strap onto pads



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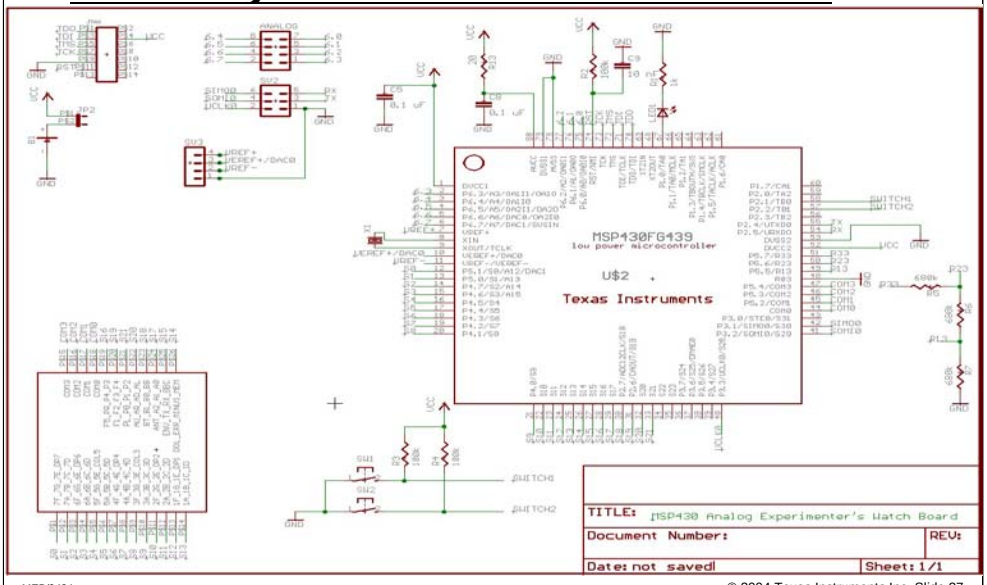
This slide provides direction on how to attach the Velcro wrist strap to the retro watch

4-30 Day Retro Watch Schematic



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MSP-430-Day-II Demo Board Schematic